



NASA SBIR 2022 Phase I Solicitation

Z10.01 Cryogenic Fluid Management

Lead Center: GRC

Participating Center(s): JSC, MSFC

Scope Title

Cryogenic Fluid Management (CFM)

Scope Description

This subtopic seeks technologies related to cryogenic propellant (e.g., hydrogen, oxygen, methane) storage and transfer to support NASA's space exploration goals. This includes a wide range of applications, scales, and environments consistent with future NASA missions. Such missions include but are not limited to upper stages, ascent and descent stages, refueling elements or aggregation stages, nuclear thermal propulsion, and in situ resource utilization. This subtopic solicits proposals in the following areas, in order of priority:

1. High-pressure-ratio compressor for on-orbit gas transfer: Design and develop concepts for a high-pressure-ratio compressor for supercritical xenon and helium, capable of increasing low-pressure fluid to 3,000 psia with continuous flow of up to 15 g/s, allowing for on-orbit transfer of gases for applications of refueling. The temperature range of the xenon is 17 to 40 Å°C. The compressor must be capable of surviving launch-load vibrations, be able to function accurately in microgravity and vacuum environment (10-5 torr), and be able to maintain gas cleanliness to Level A/10 for nonvolatile residue. For Phase I, the main deliverable should be a compressor design and performance analysis. For Phase II, the main deliverable should be a working engineering model of the compressor and the compressor itself.
2. Cryogenic flight-weight valves (minimum Cv >50, goal to Cv of ~100) for low-pressure (500 cycles with a goal of 5,000 cycles) to maximize the lifetime of the valve. Proposals can include metallic or nonmetallic sealing elements. Proposals should address the whole valve subsystem, including actuation and actuation mechanisms, with the goal of minimizing mass in Phase II. Phase I deliverable should be proof of concept of the valve with test data using liquid nitrogen, while the Phase II deliverable should be the valve.
3. Subgrid computational fluid dynamics (CFD) of the film condensation process for 1g and low gravity (lunar or martian) to be implemented into commercial industry standard CFD codes. The subgrid model should capture the formation and growth of the liquid layer as well as its movement along a wall boundary and should implement the volume of fluid (VOF) scheme. The condensation subgrid model should be validated against experimental data (with a target accuracy of 25%), with a preference for condensation data without a noncondensable. Emphasis should be placed on cryogenic fluid data, but noncryogenic data is acceptable. Phase I should be focused on simplified geometries (vertical plates/walls), while Phase II should be focused on complicated geometries (e.g., full cylindrical tank). The subgrid model and implementation scheme should be the final deliverable.
4. Development of heat flux sensors capable of measuring heat fluxes between 0.1 and 5.0 W/m2 for

cryogenic applications. The sensors should have a target uncertainty of 2% full scale or less at temperatures as high as 300 K and at least as low as 77 K with a goal of 20 K. Proposers should target a demonstration of sensor operability in the 77-K temperature range in Phase I with a full demonstration of calibration and uncertainty in Phase II. Deliverable for Phase II should be the calibrated heat flux sensor.

Expected TRL or TRL Range at completion of the Project

2 to 4

Primary Technology Taxonomy

Level 1

TX 14 Thermal Management Systems

Level 2

TX 14.1 Cryogenic Systems

Desired Deliverables of Phase I and Phase II

Hardware Software Prototype

Desired Deliverables Description

Phase I proposals should at minimum deliver proof of the concept, including some sort of testing or physical demonstration, not just a paper study. Phase II proposals should provide component validation in a laboratory environment, preferably with hardware deliverable to NASA.

State of the Art and Critical Gaps

CFM is a crosscutting technology suite that supports multiple forms of propulsion systems (nuclear and chemical), including storage, transfer, and gauging, as well as liquefaction of ISRU-produced propellants. The Space Technology Mission Directorate (STMD) has identified that CFM technologies are vital to NASA's exploration plans for multiple architectures, whether hydrogen/oxygen or methane/oxygen systems, including chemical propulsion and nuclear thermal propulsion. Several recent Phase II projects have resulted from CFM subtopics, most notably for cryocoolers, liquid acquisition devices, phase separators, broad area cooling, and composite tanks.

Relevance / Science Traceability

STMD strives to provide the technologies that are needed to enable exploration of the solar system, both manned and unmanned systems; CFM is a key technology to enable exploration. Whether liquid oxygen/liquid hydrogen or liquid oxygen/liquid methane is chosen by Artemis as the main in-space propulsion element to transport humans, CFM will be required to store propellant for up to 5 years in various orbital environments. Transfer will also be required, whether to engines or other tanks (e.g., depot/aggregation), to enable the use of cryogenic propellants that have been stored. In conjunction with ISRU, oxygen will have to be produced, liquefied, and stored; liquefaction and storage are both CFM functions for the surface of the Moon or Mars. ISRU and CFM liquefaction drastically reduces the amount of mass that has to be landed.

References

No references for this subtopic.